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(54) Sorting particulate material

(57) Particles (12) which are to be sorted are passed on a conveyor belt (10) through a split resonant cavity (18) which is subjected to a swept frequency range of electromagnetic radiation, preferably in the microwave part of the spectrum. The signals transmitted through the cavity (18) are analysed to determine whether or not they are indicative of the presence of a desired particle in the cavity. The analysis may be based on a comparison of the resonant frequency of the cavity with the particle present with the corresponding value for no particle or a known particle present. Alternatively, signal amplitude at resonance may be used for comparison purposes. The particles may be in a plurality of streams each provided with its own cavity (18) arranged side-by-side across belt (10) with screening channel dividers (36). To obviate field loss the belt carries conductive strips (40) in proximity to the edges of the side walls of the cavity halves (20, 24).

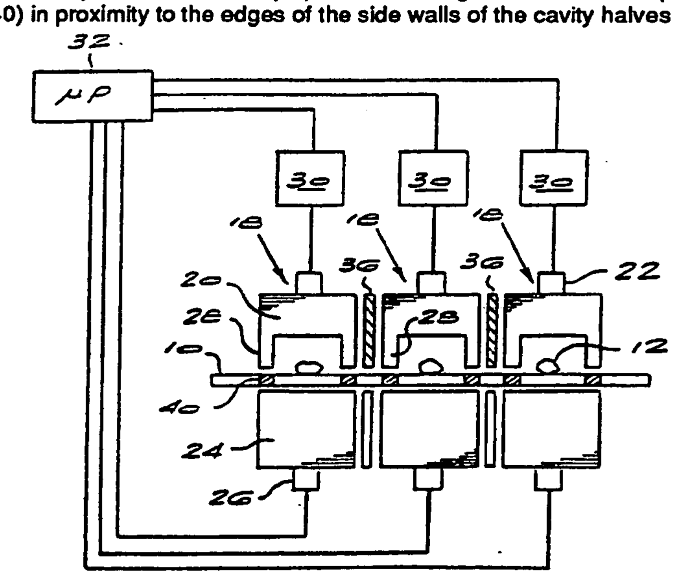

FIG 2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1982.

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FIG. 1

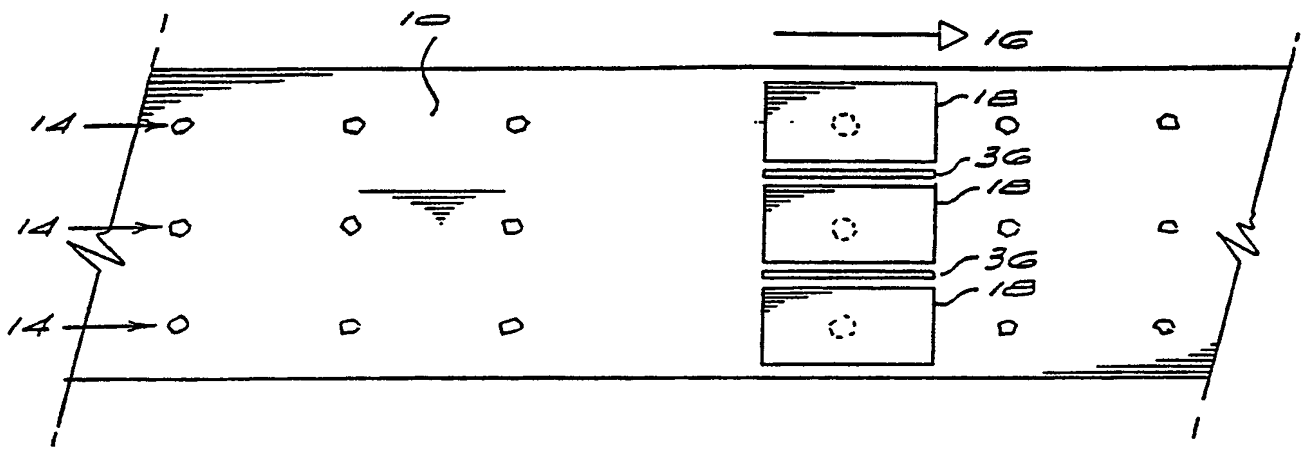
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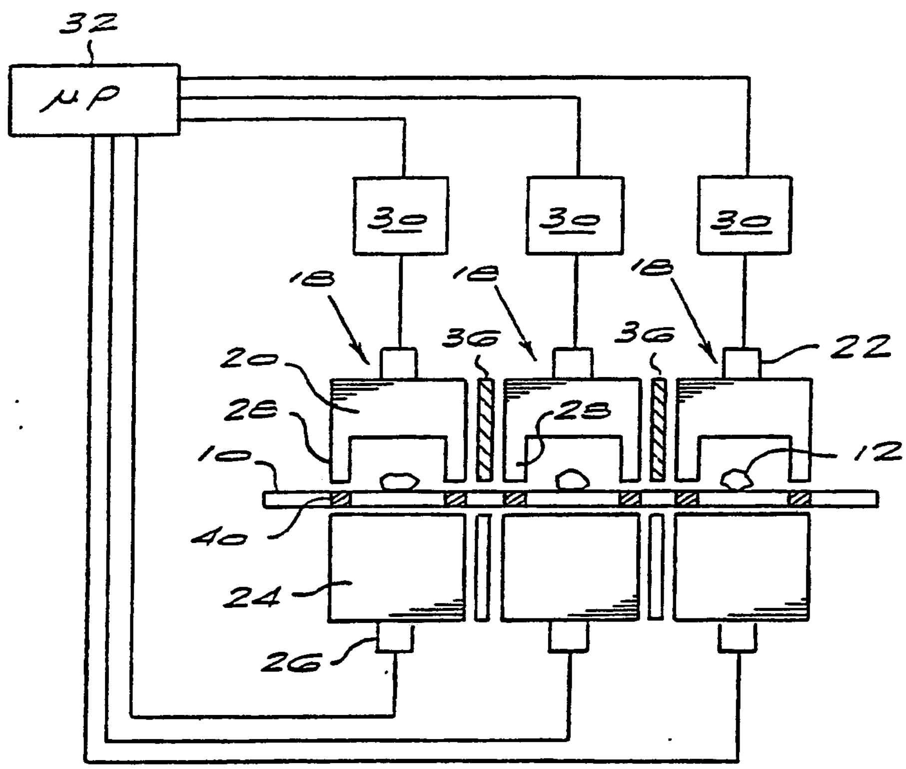
FIG. 2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- 1 -

BACKGROUND TO THE INVENTION

THIS invention relates to an apparatus and method for sorting particulate material.

It is known that a cavity or chamber of predetermined dimensions will have a certain resonant frequency when electromagnetic signals within a specified frequency range are applied to it. If a particle of material enters the space enclosed by the chamber, the presence of the particle in the chamber will result in a change in the resonant frequency and also in the amplitude of the signal transmitted by the chamber at resonance. The change in resonant frequency may be attributed to a change in the dielectric constant of the space as a result of the presence of the particle while the change in amplitude may be attributed to the electrical loss characteristic of the particle. The electrical loss characteristic is referred to in the art as the loss tangent or tan delta.

The present invention proposes to use this phenomenon in a method and apparatus for sorting particulate materials, such as ores.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, there is provided an apparatus for sorting particulate material into fractions on the basis of differences in dielectric constant or loss tangent, the apparatus comprising means for passing the particles through a resonant cavity which is split to have separate portions between which the particles pass, means for subjecting the cavity to a swept frequency range of electromagnetic radiation, means for detecting and analysing signals transmitted by the cavity, and means for separating the particles into fractions on the basis of detected changes, due to the presence of a particle in the cavity, in the resonant frequency of the cavity and/or in the amplitude of transmitted signal at resonance.

In a preferred embodiment, the frequencies in the swept range are in the microwave part of the spectrum.

The invention extends to a multi-channel sorting apparatus comprising a means for passing the particles, in parallel streams through a plurality of resonant cavities each of which is split to have separate portions between which the conveyor passes, one such cavity being provided for each stream of particles, means for subjecting each cavity to a different swept frequency range of electromagnetic radiation, means for detecting and analysing the signals transmitted by each cavity, and means for separating the particles in each stream into fractions on the basis of detected changes, due to the presence of a particle in a cavity, in resonant frequency of the cavity and/or in the amplitude of the transmitted signal at resonance.

The means for passing the particles through the or each split cavity may be a conveyor belt which passes through a gap between the portions of the cavity. Alternatively, means may be feed means for causing the particles to fall under gravity through such gap or gaps.

In the multi-channel sorter, which uses a conveyor to pair the particles between the portions of the cavities, the cavities are preferably arranged side-by-side across the width of the conveyor, which will typically be a conveyor belt, and are so arranged that one stream of particles passes through each of the cavities, the particles being spaced apart in each stream so that a single particle only is present in a cavity at a time. Suitable channel dividers may be provided between the cavities to shield them one from the other. Furthermore, one portion of each cavity, usually an upper portion disposed above the conveyor, will have side walls of which the edges are in close proximity to the belt, the height of the side walls being sufficient to permit passage of the particles on the conveyor. A further refinement is the incorporation of steel or other suitable conductive strips in the conveyor belt at positions corresponding to the edges of the side walls of the upper portion of the cavity.

A further aspect of the invention provides a method of sorting particulate material into fractions, the method comprising the steps of passing the particles in a stream between separate portions of a resonant split cavity, subjecting the cavity to a swept frequency range of electromagnetic radiation while each particle is inside the cavity, detecting and analysing the signals transmitted by the cavity, and separating the particles into fractions on the basis of the detected changes, due to the presence of a

particle in the cavity, in the resonant frequency of the cavity and/or in the amplitude of the signal transmitted by the cavity at resonance.

According to a still further aspect of the invention, the particles are passed, in a plurality of streams through resonant split cavities, one stream passing through each cavity, and subjecting each of the cavities to a different swept frequency range of electromagnetic radiation.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows a diagrammatic plan view of apparatus of the invention; and

Figure 2 shows a diagrammatic elevation view of the same apparatus, looking in the direction in which the conveyor belt moves.

SPECIFIC DESCRIPTION

Figure 1 shows a conveyor belt 10 which conveys particles 12 in a series of parallel streams 14 in the direction 16. The particles in each stream are spaced apart from one another as illustrated. Conventional particle handling equipment may be used to arrange the particles into streams with the desired spacing between the particles in each stream.

Each stream of particles passes centrally through a resonant cavity 18 which is of split construction. As seen in Figure 2, each cavity has an upper transmitter portion 20 to which a transmission line structure 22 is connected, and a lower receiver portion 24 to which a receiver line structure 26 is connected. The belt 10 passes between the portions 20 and 24 which are totally separate from one another. It will be noted that the upper portion 20 has side walls 28 of which the lower edges are very close to the upper surface of the belt 10. The structures 22 and 26 may be conventional wave guide antennae, the portions 20 and 24 and the wave guide antennae being dimensioned according to well-known microwave principles. Each structure 22 is connected to a microwave generator 30 and the signals transmitted by the cavity 18 and detected by the structures 26 are fed to a microprocessor 32 which also controls the operation of the microwave generators.

The microwave generator in each case continuously subjects each cavity to a swept frequency range of microwave radiation. The signals transmitted by the cavity and detected by the structure 26 are analysed by the microprocesser 32. The microprocessor compares the resonant frequency of the cavity, with the particle inside, i.e. between the upper and lower portions 20 and 24, with the known resonant frequency with no particle inside and makes a decision as to whether any detected change in such freqency is indicative of the presence of a desired particle. Alternatively, the comparison may be between signal amplitude at resonance with the particle present and with no particle present, the microprocessor once again deciding whether any change in such signal amplitude at resonance is due to the presence of a desired particle. A still further alternative would be for both such comparisons to be made.

Instead of comparing the detected resonant frequency and/or signal amplitude at resonance with the corresponding value for no particle present, the detected value or values may be compared with corresponding values previously determined with a known particle present in the resonant cavity 18.

Irrespective of which comparison is made, the microprocessor, on deciding that a desired particle is present, activates a downstream separation device to remove that particle from its stream. For instance, at a position downstream of the cavities 18, the belt may pass over a head pulley with the result that the particles, after passage through the cavities, are projected in free flight. Having decided that a desired particle is present, the microprocessor activates the appropriate one of a bank of fluid blast ejectors which, at the correct instant, issue a short duration blast of fluid to blast the relevant particle out of its falling stream for collection apart from other particles not selected by the microprocessor.

It will be appreciated that similar operations are being carried out simultaneously for all the streams 12. To prevent cross-channel interference, the microwave generators serving the cavities 18 are set to sweep their cavities with different frequency ranges. Furthermore, channel separators or dividers 36 of suitable insulating material are interposed between the cavities.

Although the cavities are split, the majority of the signal applied to them is propagated through them. A part of the signal may be lost through the gaps adjacent the belt and this may cause some local distortions of the electric field. The gaps should therefore be minimised as far as possible. However, the maximum attenuation of the signal i.e.

reduction in resonant signal amplitude, and the maximum frequency shift will occur at the centre of each cavity, where the field strength is greatest, and it is anticipated that the local field distortions at the gaps will not unduly affect the accuracy of the sort. With the intention of further minimising local distortions and possible resultant inaccuracies in the sort, it is proposed to incorporate strips 40 of steel or other suitable conductive material in the belt at positions corresponding to the edges of the side walls of the upper portions 20 of the cavities 18. These strips will, it is anticipated, go a long way to "closing off" the cavities 18 and to preventing signal losses.

The apparatus described above will be suitable for sorting a wide range of materials either on the basis of their size or their composition. Thus, for instance, similarly composed particles may be differentiated on the basis of differences in their size, i.e. volume, since this will affect their dielectric constant or loss tangent. On the other hand, similarly sized particles can be sorted on the basis of their different compositions. It would also be possible to differentiate between particles of different sizes and different compositions, providing that the apparatus includes means for measuring the size of each individual particle and for applying an appropriate size correction during the analysis step.

The present invention has the advantage that the use of split resonant cavities permits the simultaneous sorting of particles in a number of different streams on a single conveyor, with the result that high throughputs are possible.

In another embodiment of the invention, the particles are merely projected from a conveyor belt and allowed to fall in parallel streams, under gravity, through the split cavities which in this case would be arranged with their portions 20 and 24 on opposite sides of the particle trajectories.

CLAIMS

1.
An apparatus for sorting particulate material into fractions on the basis of differences in dielectric constant or loss tangent, the apparatus comprising means for passing the particles through a resonant cavity which is split to have separate portions between which the particles pass, means for subjecting the cavity to a swept frequency range of electromagnetic radiation, means for detecting and analysing signals transmitted by the cavity, and means for separating the particles into fractions on the basis of detected changes, due to the presence of a particle in the cavity, in the resonant frequency of the cavity and/or in the amplitude of transmitted signal at resonance.

2.
An apparatus according to Claim 1 wherein the frequencies in the swept range are in the microwave part of the spectrum.

3.
An apparatus according to either one of the preceding claims wherein the means for passing the particles through the cavity comprises a conveyor belt which passes through a gap between the separate portions of the cavity.

4.
An apparatus according to either one of Claims 1 or 2 wherein the means for passing the particles through the cavity comprises mea s for causing the particles to fall under gravity through the cavity.

5.
An apparatus according to any one of the preceding claims comprising a transmission line structure for transmitting the swept frequency range through the cavity, a receiver line structure for detecting the signals transmitted through the cavity and a microprocessor for analysing the detected signals to determine whether or not they are indicative of the presence of a desired particles in the cavity.

6.

An apparatus according to Claim 5 wherein the microprocessor compares the resonant frequency of the cavity and/or the signal amplitude at resonance with a particle present therein, with the corresponding value for the cavity in an empty state.

7.
An apparatus according to Claim 5 wherein a microprocessor compares the resonant frequency of the cavity and/or the signal amplitude at resonance with a particle present therein, with the corresponding value for the cavity with a known particle therein.

8.
An apparatus according to any one of the preceding claims comprising a conveyor belt for passing the particles through the cavity, the belt carrying conductive inserts for reducing signal losses at the edges of the cavity.

9.

A multi-channel sorting apparatus comprising means for passing the particles in parallel streams through a plurality of resonant cavities each of which is split to have separate portions between which the conveyor passes, one such cavity being provided for each stream of particles, means for subjecting each cavity to a different swept frequency range of electromagnetic radiation, means for detecting and analysing the signals transmitted by each cavity, and means for separating the particles in each stream into fractions on the basis of detected changes, due to the presence of a particle in a cavity, in resonant frequency of the cavity and/or in the amplitude of the transmitted signal at resonance.

10.

A multi-channel sorting apparatus according to Claim 9 wherein the means for passing the particles through the or each split cavity is a conveyor belt which passes through a gap between the portions of the cavity.

11.

A multi-channel sorting apparatus according to Claim 10 wherein the cavities are arranged side-by-side across the width of the conveyor belt.

12.

A multi-channel sorting apparatus according to Claim 11 and comprising channel dividers between the cavities to shield them one from the other.

13.
A multi-channel sorting apparatus according to any one of Claims 10 to 12 wherein one portion of the cavity has side walls with edges in close proximity to the conveyor belt and wherein the conveyor belt carries conductive strips extending in the direction of movement of the belt in positions corresponding to the positions of the edges of the side walls.

14.
A multi-channel sorting apparatus according to any one of Claims 9 to 13 wherein the swept frequencies are in the microwave part of the spectrum.

15.
A multi-channel sorting apparatus according to any one of Claims 9 to 14 comprising a transmission line structure for each cavity for transmitting the swept frequency range through the cavity, a receiver line structure for each cavity for detecting signals transmitted through the cavity, and a microprocessor for analysing the detected signals from each cavity to determine whether or not they are indicative of the presence in the relevant cavity of a desired particle.

16.
A multi-channel sorting apparatus according to Claim 15 wherein the microprocessor compares the resonant frequency of each cavity, with a particle therein, with the resonant frequency of the cavity in an empty state or with a known particle therein.

17.
A multi-channel sorting apparatus according to Claim 15 wherein the microprocessor compares the amplitude of the transmitted signal at resonance, with a particle present in the cavity, with the amplitude of the transmitted signal at resonance with the cavity in an empty state or with a known particle therein.

18.
A method of sorting particulate material into fractions, the method comprising the steps of passing the particles in a stream between separate portions of a resonant split cavity, subjecting the cavity to a swept frequency range of electromagnetic radiation while each particle is inside the cavity, detecting and analysing the signals transmitted by the cavity, and separating the particles into fractions on the basis of the detected changes, due to the presence of a particle in the cavity, in the resonant frequency of the cavity at resonance.

19.
A method according to Claim 18 wherein the particles are passed in a plurality of parallel stream through resonant split cavities, one stream passing through each cavity, and wherein the cavities are each subjected to a different swept frequency range of electromagnetic radiation.

20.
A method according to either one of Claims 18 or 19 wherein each swept frequency range is in the microwave part of the spectrum.

21.
A multi-channel sorting apparatus substantially as herein described with reference to the accompanying drawing.

22.
A method of sorting particles substantially as herein described with reference to the accompanying drawings.

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